IMPERIAL BUREAU OF PLANT GENETICS: HERBAGE PLANTS

BULLETIN No. 8.

(Issued also by the Imperial Bureau of Animal Nutrition, Aberdeen, as Technical Communication No. 3.)

RECENT RESEARCH ON FORAGE CROP CULTIVATION, FODDER CONSERVATION AND UTILISATION, AT THE ANIMAL BREEDING INSTITUTE OF THE UNIVERSITY, KÖNIGSBERG.

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AGRICULTURAL BUILDINGS

ABERYSTWYTH

WALES, GREAT BRITAIN

Price 1/-

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The Animal Breeding Institute of the University of Königsberg is in charge of both research and teaching in animal breeding science. From this extensive sphere, problems of animal husbandry takes first place in practical investigations and amongst those, research in forage crop cultivation and the preservation and use of fodder crops are of chief importance. The late Professor Dr. W. Völtz commenced these studies and they have been continued and extended by his colleagues.

A short review of such results of the past few years' work as are of interest from the point of view of the Bureaux of Herbage Plants and Animal Nutrition is given here.

1. *Feeding value of hay from pure grasses and mixtures of clover and grass.*

These studies have been in progress for the past six years with a view to setting up a new and practical scale of values for the feeding value of grass hay, but few results are yet available regarding grass hay of composition defined as to species, time of harvesting and mode of drying.

In order to make comparable the results from different years, the grasses were harvested at the same stage of growth, namely, " spikes just emerging from the leaf sheath."

Feeding value was estimated by digestion experiments on cows. The experimental animals were given the hay to be studied, whether hay from single species of grass or from mixtures of grass and clover, as their sole feed. In feeding tests on cows the effects of grass hay on dairy products and on appetite were also studied.

On the basis of starch equivalent the grasses could be arranged in the following order of value :

	Starch equivalent as percentage of dry substance.
1st Group.	
Meadow fescue (*Festuca pratensis*)	45—51
Timothy (*Phleum pratense*) ..	45—48
Cocksfoot (*Dactylis glomerata*) ..	38—45
Late meadow grass (*Poa serotina*)	45
2nd Group.	
Smooth stalked meadow grass (*Poa pratensis*) ..	38—44
Brome grass (*Bromus inermis*)	
Sheep's fescue (*Festuca rubra*)	
Tall oatgrass (*Avena elatior* L.)	
Meadow foxtail (*Alopecurus pratensis*)	
3rd Group.	
Fiorin (*Agrostis stolonifera*)	36—39
Reed canary grass (*Phalaris arundinacea*) ..	
Beckmannia (*Beckmannia eruciformis*)	

Pure red clover hay had a starch equivalent of 43.5 in 100 parts dry matter ; hay from grass of poor quality, chiefly sedges (*Carex*), 32.7.

The starch equivalent of perennial ryegrass (*Lolium perenne*) was determined in a mixture of aliquot parts of four cuts and found to be 43.2 per 100 parts dry matter. This value agrees with those found by Steuber and Stotz (51), 45.6 for first cut and 42.3 for second cut.

Individual grasses show considerable variation in digestible crude protein. Late meadow grass (*Poa serotina*), cocksfoot (*Dactylis glomerata*), Beckmannia (*B. eruciformis*) and meadow foxtail (*Alopecurus pratensis*) were outstandingly rich in digestible crude protein, while fiorin (*Agrostis stolonifera*) was relatively poor in protein.

Special attention was given to the correlation between fibre content and feeding value and it was shown that the correlation is not of such an order that direct digestibility tests, e.g. by Zaitschek's method (54) can be dispensed with.

Comparative digestibility tests with wethers and bullocks showed that good hay is digestible to the same extent by both. The rather lower digestibility of crude fibre by bullocks is compensated by higher digestibility of N-free extractives. Badly harvested hay of very high fibre content was better digested by bullocks than by wethers.

Mixtures of equal quantities of red clover hay and grass hay (timothy and meadow fescue) gave a slightly lower digestibility (6–9 per cent. of the starch equivalent) than grass hay alone. Mixtures of clover hay with late harvested brome grass (*Bromus inermis*) of high fibre content gave results similar to those obtained from mixtures of clover and straw [cf. the investigation of Mertins (43)].

To determine the feeding value of hay for milk cows, grass hay alone or mixed with clover hay was given as sole feed during the experimental periods. The amount of milk produced from 100 kg. hay with 85.7 per cent. dry matter, by cows giving daily yields of about 20 lbs., was calculated and the grasses grouped accordingly.

Group 1. Giving over 65 litres (143 lbs.) per 100 kg. hay:

Cocksfoot (*Dactylis glomerata*).

Timothy (*Phleum pratense*).
Meadow fescue (*Festuca pratensis*).

Group 2. Giving 60-65 litres (132-143 lbs.) per 100 kg. hay:

Smooth stalked meadow grass (*Poa pratensis*).

Sheep's fescue (*Festuca rubra*).

Group 3. Giving 55-60 litres (121-132 lbs.) per 100 kg. hay:

Late meadow grass (*Poa serotina*).

Meadow foxtail (*Alopecurus pratensis*).

Reed canary grass (*Phalaris arundinacea*).

Beckmannia (*B. eruciformis*).

Brome grass (*Bromus inermis*).

The highest milk yield from grass hay was 74 litres (163 lbs.) per 100 kg. cocksfoot. Clover hay gave 79 litres (174 lbs.) and sedge hay (*Carex*) only 40 litres (88 lbs.).

Fat content of milk was favourably affected by grass as compared with clover hay. Fat content when clover hay was fed was 3.06 per cent.; with timothy hay, 3.59 per cent.; with meadow fescue, 3.64 per cent.; with late meadow grass (*Poa serotina*), 3.76 per cent. and with smooth stalked meadow grass (*Poa pratensis*) 3.72 per cent.

Studies of the effect of feeding pure grass hay on dairy products showed that butter is firm and crumbly. Smell is normal, but flavour may be affected. Both butter and milk had a bitter taste with timothy, tall oatgrass, meadow foxtail and sheep's fescue, while sedge hay gave both milk and butter so bitter a taste that they were unfit for use.

Definite differences in palatability of the hays could not be distinguished since individuality in the animals and peculiarities of the grasses both influenced the results. Meadow fescue and timothy hay were both eaten very readily, tall oatgrass less readily; indeed one cow refused this grass altogether.

The yields are shown in Table 1.

TABLE I.

Yields of hay from grasses in pure culture calculated to 85.7 per cent. dry matter in Dz. (100 kg.) per hectare (cwt. per acre in brackets).

	1st cut.	2nd cut.	3rd cut.	Total.
Reed canary grass (*Phalaris arundinacea*)	43.2 (34.5)	34.1 (27.3)	—	77.3 (61.8)
Fiorin (*Agrostis stolonifera*)	51.0 (40.8)	14.3 (11.4)	—	65.3 (52.2)
Tall oatgrass (*Avena elatior*)	33.4 (26.7)	22.3 (17.8)	12.9 (10.3)	68.6 (54.9)
Sheep's fescue (*Festuca rubra*)	30.4 (24.3)	26.8 (21.4)	—	57.2 (45.8)
Meadow fescue (*Festuca pratensis*) ..	35.1 (28.1)	16.1 (12.9)	—	51.2 (41.0)
Timothy (*Phleum pratense*)	36.2 (29.0)	12.9 (10.3)	—	49.1 (39.3)
Cocksfoot (*Dactylis glomerata*)	29.7 (23.8)	16.8 (13.4)	—	46.5 (37.2)
Smooth stalked meadow grass (*Poa pratensis*)	23.9 (19.1)	22.7 (18.2)	—	46.6 (37.3)

If the yield of digestible nutrients be calculated from these figures and those for starch equivalent and digestible crude protein, it appears that reed canary grass gives the highest yield. Tall oatgrass comes next, provided that three cuts are made so that the high rate of growth of this grass is fully utilised. Meadow fescue follows in respect of starch equivalent and smooth stalked meadow grass for protein yield.

2. *Comparative investigations on loss of nutrients in the conservation of green fodder by different methods.*

Detailed investigations have been made by Bernecker (1) on the losses occurring in frame drying a clover and grass mixture (red and green clover, *Trifolium pratense* and *Trifolium hybridum*, 43.8 per cent.; grasses, chiefly timothy (*Phleum pratense*), 53.2 per cent. ; weeds, 3 per cent.), the results with two and with three cuts being compared. The losses were compared with those of the same mixture artificially dried without loss and are given as percentages of the quantities harvested.

	Dry matter.	*Digestible crude protein.*	*Starch Equivalent.*
Three cuts ..	16.91	20.40	25.38
Two cuts ..	11.69	28.77	40.91

Yield of dry matter with three cuts was 47.65 Dz. per hectare (roughly 38 cwts. per acre), with two cuts 65.07 Dz. (52 cwts.). Gross yield is therefore reduced by repeated cutting, but both protein content and feeding value of grass cut thrice and dried on frames are higher than those of grass cut twice. The yields in Dz. per hectare (cwt. per acre in brackets) were as follows :—

	Digestible crude protein.	*Starch Equivalent.*
Three cuts	..5.43 (4.3)	25.35 (20.3)
Two cuts ..	..4.06 (3.2)	21.75 (17.4)

Protein yield was therefore 33.7 per cent. and starch equivalent 16.5 per cent. higher with three cuts than with two. These figures hold only for yield as hay. Taking yield of fresh substance, as for instance in silage (cold fermentation) in tower silos, the gain in digestible crude protein with three cuts is only 19.7 per cent. as compared to two cuts, while the yield of starch equivalent is less by 7.7 per cent., corresponding to the smaller total yield of dry matter. The losses due to the drying of hay, which are particularly heavy with two cuts, do not appear in this case.

Hildebrandt (6) and Lepehne (41) have carried out further qualitative tests on losses in clover after two cuts and three cuts, dried either on frames or on the ground. In frame drying 25.3 per cent. of digestible crude protein and 42.0 per cent. of starch equivalent were lost ; in drying on the ground, 55.8 per cent. of protein and 63.9 per cent. of starch equivalent. Weather was bad in both cases. Similar observations were made on meadow grass by Hirsch (12), Burchardt (3) and Jantzon and Kirsch (14). The results agree with those for clover. With three cuts a higher yield of digestible crude protein was obtained, but no increase in starch equivalent as compared with two cuts. Again, drying on frames was shown to be better, especially during rainy weather when losses are high. Kirsch (15) discusses the practical significance of these results.

The question of losses due to different methods of conservation of meadow grass has recently been taken up again and quantitative determinations made of the losses due to drying hay on the ground, or on frames (Allgäuer Hütten), ensiling in tower silos and conservation by the Dutch stack process. The results [cf. Rehbock (45)] are summarised as follows :—

TABLE II.

Percentage losses during conservation of meadow grass by different methods compared with hay artificially dried without loss.

	Yield.	Digestible crude protein.	Starch Equivalent.
Hay dried on the ground	23.6	53.9	54.5
Hay dried on frames	11.6	8.6	23.7
Silage (cold fermentation) in tower silos ..	7.4	4.4	—
Silage (Dutch stack process)	33.9	87.4	48.8

Here again the advantage of drying hay on frames and the very small loss of nutrients in silage making are evident. Unavoidable losses do, of course, occur in silage making and the apparent constancy of starch equivalent depends on changes in digestible fibre.

The loss of digestible protein in Dutch stack silage* is particularly high and is due to the heating (70°C.) which occurs in the stack.

From these investigations the following conclusions may be drawn :

(1) Losses due to drying hay on the ground are usually underestimated. Even in good weather these are, in general practice, seldom less than 50 per cent of the digestible nutrients.

On the other hand the advantages of drying on frames are probably overestimated since the losses of digestible nutrients are below 30 per cent. only in good weather.*

(2) Amongst practical methods of conserving green fodder, silage making (lactic acid fermentation at low temperatures) shows least loss of nutrients.

The Dutch stack process should not be used for fodder high in protein where silage can be laid down or hay dried on frames.

3.—*Investigations on the ensilage of green crops.*

(a) *Technique.*

All investigations on the technique of silage making have shown that two main conditions are necessary for the preparation of a suitable fodder : (1) the fresh material must be firmly packed, and (2) air must be excluded.

Additions of sugar to improve the medium for the growth of lactic acid bacteria and of acid to ensure a low pH during the early stages of the process are merely safeguards and are themselves of no value if the essential conditions mentioned above are not fulfilled.

Acidification (e.g., with hydrochloric acid solutions) is of special importance when it is desired to produce good silage from green crops, packed without chopping, in simple wooden silos.

In view of the favourable results with acidification of green crops reported by Virtanen in Finland (A.I.V. silage) experiments were made with hydrochloric acid solutions to which small quantities of phosphoric acid were added [Kirsch (16), Hildebrandt (7), Kirsch and Hildebrandt (17, 18)]. It has been shown (unpublished results) that addition of HCl to the extent of 0.3 per cent. of the fresh weight of the crop, with clover and aftermath, by inhibiting

*Cf. investigation of Woodman and Hanley (52) and Woodman (53).

*These results have recently been fully confirmed by independent workers [Crasemann and Steiner (47)] in Switzerland. Losses of starch equivalent in drying hay on the ground were on the average 51 per cent. ; in drying on frames (Steinach Hütten and Allgäu Heinzen) 40 per cent. With the most favourable weather conditions (hay dried in three days without rain) losses of starch equivalent in drying on the ground were still 40 per cent., while losses in drying on frames after continued rain were as high as 45 to 52 per cent.

the growth of undesirable bacteria, sensitive to acid, promotes the growth of lactic acid bacteria. In a relatively short time the added acid is no longer detectable as free acid, which is of great importance from the feeding point of view. As the added acid disappears, lactic acid fermentation increases. The " sterilisation " phase is followed by the " fermentation " phase [cf. Ruschmann (49)]. The final product is a silage showing chiefly lactic acid fermentation, a result which may also be achieved without addition of acid by strict observance of the fundamental conditions. In order to ensure that lactic acid fermentation shall not be inhibited, since lactic acid silage is of high feeding value and of good vitamin content [cf. Kirsch, (19)], addition of sugar to crops rich in protein is also to be recommended. Smaller quantities of sugar are required with acid than when sugar alone is added.

Comparative tests on the effect of adding acid on digestibility and feeding value have shown that with potatoes [Gramatzki (5)], marrow-stem kale [Kirsch and Weinert (20)], and red clover and meadow grass [partly published, Kirsch (16, 21)] there was no difference between silage made with and that made without acid. There was little difference in composition of the acids present except that acetic acid was usually very low and acidity chiefly due to lactic acid in the silage treated with acid.

Since simple wooden containers, sunk in the ground without floors, are in use for making silage, tests were made of the loss of feeding value in such containers as compared with non-porous (tower) silos. In comparative tests on pigs with potatoes [Gramatzki (5) and Kirsch (21)] ensiled with and without acid and showing chiefly lactic acid fermentation, the loss of digestible nutrients in either type of silo was practically zero, while that of potatoes in pits was from 6 to 11 per cent.

Estimations of the loss from forage crops in drained tower silos [Hofer (13)] showed considerable differences depending on the original dry matter content of the crop. Vetches with 25 per cent. dry matter lost no liquid even when loaded with three times their weight of earth. Young clover with 16 per cent. dry matter under similar conditions lost 10 per cent. of the original weight. Loss of dry matter amounted to 3 per cent. ; of crude protein, chiefly amides, 5 per cent. ; of N-free extractives, 3 per cent. of that originally present. Such losses are small, but not altogether negligible in crops such as potatoes. From the point of view of retaining the maximum amount of nutrients in the silage, impermeable containers (tower silos) with or without acid, are best ; pit silos and stacks should be used only when there is no alternative.

It has been claimed for various chemical preparations that they " sterilise " the crop to be ensiled (by formation of gas ?). Of these, one, " Toro-Silon," which is stated to give excellent silage even in pits, has been tested [Lukaczewicz (42)]. The test was made on a crop rich in protein (clover and grass) since plants rich in carbohydrates such as beet leaves and maize do not, in general, require any special treatment. Toro-Silon did not produce good silage either in tower or in pit silos, and so must be taken as useless for the conservation of green crops rich in protein.

Investigations on the suitability of other acids for use in silage making and of hydrochloric acid in solid form (Penthesta, made by I. G. Farbenindustrie) are in progress.

In ensiling potatoes, both practical experience and experiment [Hildebrandt and Lemke (11)] have shown that the potatoes should not be steamed in the silo. However great the advantage of steaming in the silo may appear, from the point of view of saving labour, there are a number of disadvantages, the chief of which is the danger of discolouration and loss of feeding value [see also Ruschmann (50)]. Schmidt's special apparatus is designed to allow steaming and filling to be carried on in one process [Kirsch (28)].

(*b*) *Feeding value of different silage crops.*

A review of experimental work up to 1930 is given in " Silage making by the cold fermentation process" [Kirsch and Hildebrandt (22)]. Further studies have since been made with pigs on the specific effects of lactic and other acids on feed utilisation and appetite during fattening on potatoes [Kirsch, Reisch and Jantzon (23)].

It was shown that lactic and butyric acids have no effect but that acetic acid in large quantities is toxic. The results agree with those of Liebscher's (48) metabolism experiments on wethers in which acetic acid was found to have a harmful effect and lactic acid none or a beneficial effect. More extensive experiments with pigs and cattle to test the effect of the organic acids formed in silage on absorption of organic and inorganic food constituents are in progress. Reference may be made here to work designed to show whether the amides produced in considerable quantities in silage can be utilised by milk cows [Kirsch and Jantzon (24.)]. Comparative metabolism tests were made with clover hay, clover silage and clover silage with ammonium bicarbonate (NH_4HCO_3). The rations were so arranged that the animals required to use the amides as a supply of nitrogen. Balances were positive in the experiments with silage, and even in the periods with NH_4HCO_3 addition, when almost all the nitrogen was supplied as amides and ammonium salts, nitrogen balances were still positive.

Reference may also be made to work in which it has been shown that protein decomposition in silage is due chiefly to the action of proteolytic enzymes in the plant cells, and therefore, from the nutritional point of view, would be expected to be harmless [Reetz (44) and Kirsch (25)].

Special studies have been made on marrow-stem kale as a plant particularly suited for ensiling. Kale silage shows very high digestibility. Green kale gives 13.65 kg. digestible crude protein and 70.6 kg. starch equivalent per 100 kg. dry matter [Kirsch and Weinert (20)], values which, taken together, probably exceed those of any other forage plant.

Attention has been given throughout this work to finding forage crops which will give a sufficient yield with satisfactory protein content on light soils, especially in East Germany, and be suitable for silage. Such crops must be capable of cultivation without sacrifice of cereal acreage. Tests have been made with mixtures of hemp and vetches, oil radish and vetches [Kirsch and Jantzon 26], mixtures of brome grass and tufted vetch and of birdsfoot trefoil and oil radish [Kirsch and Jantzon (27)].

A special study has been made of lupin silage (*Lupinus angustifolius*) and silage from pasture containing *Equisetum* (*E. palustre*) to determine whether fermentation at temperatures up to 60°C. would reduce the toxic effects of the lupin alkaloids and poisonous substances in equisetum [Kasprzik (40)]. Heat fermentation in lupin silage caused a considerable reduction in digestible protein. Cold fermentation gave a good silage which was taken by milk cows, when they had become accustomed to it, in quantities up to 25 kg. per head per day. When 30 kg. daily were taken, digestive disturbances occurred, probably on account of the alkaloids present. Symptoms of lupin poisoning were not observed. Estimation of alkaloids showed no diminution in the silage (fermentation at temperatures up to 60° C.) and biological experiments (injection of aqueous extracts into mice) led to the same conclusion. Nor did heat fermentation of pasture containing *Equisetum* cause any reduction of toxicity. It is still possible that higher temperatures, as in stack silage, might reduce or destroy the toxic substance, but then large losses of digestible nutrients, especially protein, would be inevitable. Experiments are in progress.

Investigations into the feeding value of potatoes that have been washed, steamed and then ensiled [Flegel (4) and Bollmann (2)] have shown that ensiled steamed potatoes are equally well digested, as readily eaten and utilised to the same extent by all classes of stock as potatoes freshly steamed daily [Kirsch (28)].

(c) *Silage in farm management.*

The practical side of silage making has been studied by the Institute of Animal Breeding in collaboration with the East Prussian Siloring (Advisory Board for practical farmers of the Chamber of Agriculture), with farmers and with the experimental farm of the Institute.

Investigations on potato silage and its place in farm management have been concluded [Kirsch and Hildebrandt (29)]. Questions of feeding value, of the correct mode of ensiling [Hildebrandt and Lemke (8), Völtz and Hildebrandt (46)] and of losses in silage making [Kirsch and Jantzon (30), Hildebrandt and Lemke (9)] have been

settled. As a result, the storage of feeding potatoes in clamps and cellars may be taken as uneconomical, while the ensiling of steamed potatoes allows of practically indefinite storage so that the feeder has available at all times a satisfactory basic feed. The relative value of silage compared with the products of other methods of conservation, for instance drying (potato flakes), has also been defined [Kirsch (31) and Hildebrandt (10)].

With reference to the place of silage in general farm management, investigations on field beans may be instanced [Kirsch, Hildebrandt and Lemke (32, 33)]. Beans were ensiled at different stages during growth and when ripe and, from the percentage of digestible crude protein and starch equivalent on dry matter at the different stages, the best stage for silage making was shown to be "when the beans are fully formed, the plants still green and the lower leaves beginning to die back." This stage is designated as "silo maturity." The plants are then so large that they must be chopped before ensiling. Comparison of the nutritive value of silage with that of beans harvested ripe gave the following results per 100 parts dry matter :—

	Digestible crude protein	*Starch Equivalent.*
Bean silage ..	8.63	54.9
Ripe beans with straw (dried in the field) ..	7.29	31.5

Yields per unit area in Dz. per hectare (cwt. per acre in brackets) were as follows :

	Digestible crude protein		*Starch Equivalent.*	
Bean silage	6.88	(5.50)	41.2	(33.0)
Ripe beans with straw (dried in the field)	3.54	(2.76)	15.3	(12.2)

These results were checked by an exact metabolism experiment on milk cows in which silage (silo ripe beans) gave about double the feeding value per unit area given by field dried beans including straw.

In addition to the advantage of higher feeding value, there is the further gain in using field beans for silage that they are harvested earlier and so can be used as a crop to precede winter corn, a fact which is of great importance in East Germany.

Results are also available from three years' investigations on yields of beet, maize and sunflower and on maize and sunflower silage [Kirsch and Jantzon (34, 36), Kirsch (37)]. Yield of starch equivalent has been highest for beet in all three years. If the yield of beet leaf silage be included the excess for beet becomes very considerable. Further the ensiling of sunflowers and maize involves special costs. It may therefore be stated definitely that when a beet yield of 600 Dz. per hectare (480 cwts. per acre) or more can be guaranteed, there should be no question of replacing beet by maize or sunflower in East Germany.

Similar tests have been made to compare marrow-stem kale with beet and maize [Kirsch and Hildebrandt (38)].

Experiments in feeding silage to horses gave good results [Kirsch (39)].

In conclusion, now that questions of technique and losses in conservation have been practically settled, the main problem as regards silage is to produce more, and more nutritive, fodder without extending the crop acreage at the expense of cereal crops. Further, the benefits of silage making must be defined, not only in general, for that has already been done, but in individual cases so that conversion on the basis of conservation to silage need involve no risk.

REFERENCES.

I

The studies from the Animal Breeding Institute of the University of Königsberg upon which the preceding Report is based.

W. VÖLTZ, E. REISCH and H. JANTZON. Untersuchungen über die chemische Zusammensetzung und den Futterwert einzelner Gräser. *I. Mitteilung.*

Der Gehalt des Wiesenlieschgrases oder Timotheegrases (Phleum pratense), des Wiesenschwingels (Festuca pratensis) und der Beckmannia (Beckmannia eruciformis) an Roh- und verdaulichen Nährstoffen und Stärkewert.

Arb. Landw. Kammer Prov. Ostpreussen No. 55, 1927. (*Herb. Abst.* 2, 4, 1932).

W. VÖLTZ, E. REISCH, W. KIRSCH, W. KORTHALS and G. BIENKO. Untersuchungen über die chemische Zusammensetzung und den Futterwert einzelner Gräser. *II. Mitteilung.*

Der Gehalt des Wiesenfuchsschwanzes (Alopecurus pratensis), der Fruchtbaren Rispe (Poa serotina), des Rohrglanzgrases (Phalaris arundinacea) und des Seggenheues (Carex) in dem gleichen Vegetationsstadium an Roh- und verdaulichen Nährstoffen und Stärkewert.

Die Verwertung von Wiesenfuchsschwanz, Fruchtbarer Rispe, Beckmannia und Seggenheu für die Milchleistung und ihr Gehalt an Vitaminen.

Arb. Landw. Kammer Prov. Ostpreussen No. 57, 1928. (*Herb. Abst.* 2, 4, 1932).

E. REISCH, H. JANTZON and W. KIRSCH. Untersuchungen über die chemische Zusammensetzung und den Futterwert einzelner Gräser. *III. Mitteilung.*

Der Gehalt des Englischen Raygrases (Lolium perenne), des Rohrglanzgrases (Phalaris arundinacea), des Knaulgrases (Dactylis glomerata), des Kriechenden Rotschwingels (Festuca rubra), des Wiesenschwingels (Festuca pratensis) und der Wehrlosen Trespe (Bromus inermis) an Roh- und verdaulichen Nährstoffen und an Stärkewert.

Die Verwertung von Rohrglanzgras Knaulgras, Englischem Raygras, Kriechendem Rotschwingel und Wiesenschwingel für die Milchleistung.

Arb. Landw. Kammer Prov. Ostpreussen No. 59, 1929. (*Herb. Abst.* 2, 4, 1932).

W. KIRSCH, E. REISCH and H. JANTZON. Untersuchungen über die chemische Zusammensetzung und den Futterwert einzelner Gräser. *IV. Mitteilung.*

Der Gehalt an Roh- und verdaulichen Nährstoffen und an Stärkewert im Knaulgras, Timothee, Wiesenschwingel, Französischen Raygras (Avena elatior), Rohrglanzgras und Fioringras (Agrostis stolonifera). Die Verwertung von Knaulgras, Timothee und Wiesenschwingel für die Milchleistung.

Arb. Landw. Kammer Prov. Ostpreussen No. 61, 1930. (*Herb. Abst.* 2, 4, 1932).

W. KIRSCH, E. REISCH and H. JANTZON. Untersuchungen über die chemische Zusammensetzung und den Futterwert einzelner Gräser. *V. Mitteilung.*

Der Gehalt an Roh- und verdaulichen Nährstoffen und an Stärkewert bei Wiesenrispe (Poa pratensis), Timothee, Wiesenschwingel, Kriechendem Rotschwingel, Knaulgras, Rohrglanzgras, Fioringras und Französischem Raygras. Die Verwertung von Wiesenrispe, Französischem Raygras, kriechendem Rotschwingel und Timothee für die Milchleistung.

Arb. Landw. Kammer Prov. Ostpreussen. No. 65, 1931. (*Herb. Abst.* 2, 4, 1932).

E. REISCH, H. JANTZON and W. KIRSCH. Untersuchungen über die chemische Zusammensetzung und den Futterwert von Gräsern und Kleegrasgemischen. *VI. Mitteilung.*

Der Gehalt an Roh- und verdaulichen Nährstoffen und an Stärkewerten bei Rotklee (Trifolium pratense), Wiesenschwingel, Timothee, Wehrloser Trespe und Gemischen von Rotklee mit jedem dieser Gräser.

Die Verwertung von Rotklee, von diesen Gräsern und Kleegras-Gemischen für die Milchleistung.
Arb. Landw. Kammer Prov. Ostpreussen No. 66, 1932.

A summary of these six communications is contained in :—

K. FEEDER. Untersuchungen über den Futterwert des Heues von rein gezüchteten Gräsern und Kleegrasgemischen mit bekanntem Mengenverhältnis. Dissertation Königsberg Pr., 1932.
(Not yet appeared in print).

II

Papers by members of the staff of the Institute in Journals and other publications to which reference is made in the text.

1. BERNECKER, H. Zur Kenntnis der Erträge an Rohnährstoffen, verdaulichen Nährstoffen und an Stärkewerten bei der dreimaligen Mahd eines Kleegrasgemisches gegenüber der zweimaligen Mahd.
Z. Züchtg. B. **17**, 413-43, 1930.

2. BOLLMANN, W. Untersuchungen über die Verdaulichkeit der Nährstoffe von rohen, gedämpften und gedämpft eingesäuerten Kartoffeln am Schwein, am Hammel, an der Milchkuh und an Mastochsen.
Z. Züchtg, B. **24**, 329-58, 1932.

3. BURCHARDT, W. Die Erträge der Wiesenpflanzen an Rohnährstoffen, an verdaulichen Nährstoffen und an Stärkewert je Hektar bei dreimaliger Mahd ohne mechanische Verluste. Atmungsverluste bei dreimaliger Mahd. Die Erträge an Roh- und verdaulichen Nährstoffen bei zweimaliger Mahd. Dissertation Königsberg Pr. 1926.

4. FLEGEL, K. Futterwert und Nährstoffverluste von Kartoffeln in verschiedenen Verwendungsformen.
Z. Züchtg. B. **22**, 34-75, 1931.

5. GRAMATZKI, F. Einfluss der bei der Silofutterbereitung entstehenden Säuren auf die Resorption der Nährstoffe und des Ca und P nach Versuchen am Rind, Schaf und Schwein (unter besonderer Berücksichtigung der Ansäuerung des Grünfütters mit HCl-Lösungen).
(Not yet published).

6. HILDEBRANDT, H. Zur Kenntnis der Verluste des Rotklees an Roh- und an verdaulichen Nährstoffen bei der Trocknung auf Pyramiden.
Z. Züchtg. **7**, 219-251, 1926.

7. ———— Die praktische Durchführung des Säurezusatzes beim Kaltgärverfahren. Bericht über die 9. Mitgliederversammlung des Vereins zur Förderung der Futterkonservierung e. V., Berlin 1932.

8. HILDEBRANDT, H. and LEMKE, K. Etwas über das direkte Dämpfen von Kartoffeln im Silo und in der Erdgrube.
Georgine, **108** Nr. 87, 1931.

9. ———— Untersuchungen über die Verluste von frisch aufbewahrten Kartoffeln in Erdmieten und über die Verwertung von gedämpften, in Betongruben eingesäuerten Kartoffeln bei der Schweinemast.
Die Kartoffel, **10**, 238, 1930.

10. HILDEBRANDT, H. Kartoffeltrocknung oder Kartoffel-Einsäuerung ?
Georgine, **107**, Nr. 42, 1930.

11. HILDEBRANDT, H. and LEMKE, K. Untersuchungen über das Dämpfen von Kartoffeln im Silo.
Die Futterkonservierung, **3**, 72-80, 1931.

12. HIRSCH, S. Zur Kenntnis der Wiesenerträge an verdaulichen Nährstoffen und an Stärkewert bei zwei- und dreimaliger Mahd sowie bei verschiedener Düngung. *Z. Züchtg*, **11**, 409-431, 1928.

13. HOFER, O. Ueber die Zusammensetzung von Pflanzensäften und über die durch Saftabfluss aus undichten Silobehältern entstehenden Nährstoffverluste. *Z. Züchtg.* **14**, 381-398, 1929.

14. JANTZON, H. and KIRSCH, W. Ueber die Erträge an Roh- und verdaulichen Nährstoffen bei zwei- und dreimaliger Wiesenmahd nach verschiedener Düngung.
Wiss. Arch. Landw. B. **1**, 126, 1929.

15. KIRSCH, W. Die Erträge und Verluste an Roh- und verdaulichen Nährstoffen bei der zwei- und dreimaligen Mahd von Klee- und Wiesengras nach den Versuchen des Königsberger Tierzucht-Instituts.
Tierernähr. **1**, 104-118, 1929.

16. KIRSCH, W. Grundlegende Versuche zur vereinfachten und verbilligten Anwendung der Kaltvergärung durch Säurezusatz.
a) Untersuchungen über die Wirkung von Säurezusätzen auf die Konservierung und Beschaffenheit des Silofutters.
Bericht über die 9. Mitgliederversammlung des Vereins zur Förderung der Futterkonservierung e. V., Berlin, 1932.

17. KIRSCH, W. and HILDEBRANDT, H. Arbeitsvorschriften für die praktische Durchführung der Kaltvergärung mit Ansäuerung des Grünfutters.
Bericht über die 9. Mitgliederversammlung des Vereins zur Förderung der Futterkonservierung e. V., Berlin, 1932.

18. ——— Ein bedeutungsvoller Fortschritt in der Grünfutterkonservierung.
Georgine, **109**, Nr. 20, 23, 25, 27, 28, 30 und 31, 1932.

19. KIRSCH, W. Die Entgiftung eines überständigen Grases durch die Silofutterbereitung (milchsaure Gärung), über seinen Vitamingehalt und den der Silage.
Z. Tierzüchtg, **14**, 333-380, 1929.

20. KIRSCH, W. and WEINERT, H. Untersuchungen über den Gehalt des roten und grünen Markstammkohls an rohen und verdaulichen Nährstoffen und seine Eignung für die Silofutterbereitung.
Züchtungskunde, **7**, 144-149, 1932.

21. KIRSCH, W. Der heutige Stand der Silofutterbereitung in Wissenschaft und Praxis.
Bericht auf der gemeinsamen Versammlung der Dünger- und Futterabteilung der D. L. G., Herbsttagung, Danzig, 1932.
(To appear in *Mitt. deuts. LandwGes.*)

22. KIRSCH, W. and HILDEBRANDT, H. Die Silofutterbereitung nach dem Kaltgärverfahren. Berlin 1930, Verlag Paul Parey.

23. KIRSCH, W., REISCH, E. and JANTZON, H. Der Einfluss von milch- und essigsauren Kartoffeln auf die Entwicklung und die Schlachtqualität von Mastschweinen im Vergleich zu Magermilch-Gersten-Fütterung.
Z. Züchtg, B. **21**, 504-13, 1931.

24. KIRSCH, W. and JANTZON, H. Untersuchungen über die Verwertung von Amiden und Ammonsalzen durch den Wiederkäuer mit besonderer Berücksichtigung des bei der Grünfuttereinsäuerung abgebauten Eiweisses. Nach Versuchen an Milchkühen und Schafen. *I. Mitteilung.*
(Not yet published).

25. KIRSCH, W. Weitere Feststellungen zum Eiweissabbau bei milchsaurer Vergärung grüner Pflanzen unter wechselseitiger Ausschaltung der Bakterien und proteolytischen Fermente.
Die Futterkonservierung, **2**, 127-133, 1930.

26. KIRSCH, W. and JANTZON, H. Der Gehalt an Roh- und verdaulichen Nährstoffen aus Silofutter :
a) aus Hanf- und Wicken-Gemenge,
b) aus Oelrettich- und Wicken-Gemenge.
Tierernähr, **3**, 3-12, 1931.

27. ——— Der Gehalt an Roh- und verdaulichen Nährstoffen von Silofutter aus einem Gemenge von Wehrloser Trespe und Zottelwicke ; aus Serradella-Oelrettich-Gemenge.
Tierernähr, **4**, 265-69, 1932.

28. KIRSCH, W. Die Kartoffeleinsäuerung und der Wert der eingesäuerten Kartoffeln für die Fütterung.
Deuts. landw. Tierzucht. 1931 Nr. 51.

29. KIRSCH, W. and HILDEBRANDT, H Erfahrungen mit der Verfütterung eingesäuerter Kartoffeln.
Flugbl. No. 33. *Deuts. Kartoffelbau Ges.* Berlin, 1931.

30. KIRSCH, W. and JANTZON, H. Quantitative Untersuchungen über die Nährstoffverluste bei der Lagerung von Kartoffeln und Rüben in Miete und Keller.
Tierernähr **4**, 240-48, 1932.

31. KIRSCH, W. Vergleichende Fütterungsversuche an Schweinen
1) mit gedämpften Kartoffeln,
2) mit gedämpft gesäuerten Kartoffeln,
3) mit Kartoffelflocken,
4) mit Flocken und gesäuerten Kartoffeln 1 : 1.
Georgine **107**, 280, 1930. (*Cf.* also Flegel, No. 4).

32. KIRSCH, W., HILDEBRANDT, H. and LEMKE, K. Der Ertrag an Roh- und verdaulichen Nährstoffen bei Ackerbohnen in verschiedenen Vegetationsstadien und ihre Eignung für die Silofutterbereitung.
Die Futterkonservierung, **3**, 63, 1931. (*Cf.* also *Deuts. Landw. Pr.* No. 27, 1931).

33. ——— Der Wert von eingesäuerten und getrockneten Ackerbohnen für die Milchviehfütterung.
Mitt. deuts. LandwGes. **47**, 740-2, 1932.

34. KIRSCH, W. and JANTZON, H. Vergleichende Untersuchungen
1) über die Erträge an Roh- und verdaulichen Nährstoffen bei Rüben, Mais und Sonnenblumen
2) über den Futterwert der Mais- und Sonnenblumen- Silage und der Rüben für die Milchleistung unter Berücksichtigung der Anbau-, Ernte- und Konservierungs-Kosten.
I. Mitteilung.
Die Futterkonservierung, **2**, 158-171, 1930.

35. ——— Vergleichende Untersuchungen
1) über die Erträge an Roh- und verdaulichen Nährstoffen bei Rüben, Mais und Sonnenblumen,
2) über den Futterwert der Mais- und Sonnenblumen-Silage für die Milchleistung. *II. Mitteilung.*
Die Futterkonservierung, **3**, 193-206, 1932.

36 ——————— Vergleichende Untersuchungen über die Erträge an Roh- und verdaulichen Nährstoffen bei Rüben, Mais und Sonnenblumen unter Berücksichtigung verschiedener Maissorten und der Rübenblätter. *III. Mitteilung. Die Futterkonservierung* (In the press).

37. KIRSCH, W. Erträge, Kosten und Futterwert von Mais-, Sonnenblumen- und Bohnen-Silage im Vergleich zu Rüben. *Georgine*, **107**, Nr. 75, 1930.

38. KIRSCH, W. and HILDEBRANDT, H. Der Markstammkohl, eine überaus wichtige Futterpflanze. *Georgine*, **109**, Nr. 30, 1932.

39. KIRSCH, W. Neuere Forschungen auf dem Gebiet der Pferdefütterung. *Georgine*, **109**, Nr. 29, 1932.

40. KASPRZIK, B. Einsäuerungsversuche mit Schachtelhalmhaltigem Gras und mit Lupinen nach dem Warm- und Kaltgärverfahren unter besonderer Berücksichtigung des Verhaltens der Lupinen-Alkaloide. *Z. Züchtg. B.* **25**, 111-145, 1932.

41. LEPEHNE, G. Zur Kenntnis der Nährstoffverluste von Rotklee bei zweimaliger Mahd und Erdbodentrocknung. *Z. Tierzüchtg.* **8**, 379-407, 1927.

42. LUKACZEWICZ, J. Quantitative Untersuchungen über die Nährstoffverluste bei der Grünfutter-Einsäuerung mit chemischen und natürlichen Zusatzmitteln (Defu-Lösung, Penthesta, Toro-Silon, eiweisshaltigen und eiweissfreien sauren Molken). (Not yet published).

43. MERTINS, H. Untersuchungen über die Verdaulichkeit von Einzelfuttermitteln und Futtergemischen unter besonderer Berücksichtigung ihrer Abhängigkeit vom Nährstoffverhältnis. *Z. Züchtg, B.* (In the press).

44. REETZ, B. Zur Kenntnis des Eiweissabbaues bei der Ensilierung. *Z. Tierzüchtg*, **13**, 93-119, 1928.

45. REHBOCK, H. J. Vergleichende Untersuchungen über die Konservierungsverluste und den Futterwert von Wiesengras bei Feimengras-Herstellung, Silofutterbereitung und Heuwerbung. *Z. Züchtg. B.* (In the press).

46. VÖLTZ, W. Wie sind die Kartoffeln einzusäuern ? *Flugbl. No.* 5. *Kartoffelbau Ges.* Berlin, 1930. (Revised by H. Hildebrandt).

III.

Literature from other centres to which reference is made in the text.

47. CRASEMANN, E. and STEINER, W. Vergleichende Dürrfutterernteversuche, Bodentrocknung, Steinacher Heuhütten, Allgäuer Heinzen. *Jber. kant. landw. Sch. Strickhof*, Zürich. 1930-31.

48. LIEBSCHER, K. Beitrag zur Kenntnis des Einflusses von Milch-, Essig- und Buttersäure auf die Resorption der Nährstoffe sowie auf den Kalzium- und Phosphorsäure-Stoffwechsel nach Versuchen am Wiederkäuer. *Z. Züchtg. B.* **23**, 95-122, 1932.

49. RUSCHMANN, G. Der Einfluss des Zusatzes von Säure auf die Bakterientätigkeit im Grünfutter. Bericht über die 9. Mitgliederversammlung des Vereins zur Förderung der Futterkonservierung e.V., Berlin, 1932.

50. ——— Das Braunwerden der Kartoffeln beim Dämpfen und ihre schlechte Säuerung. (Kartoffel-Silage). *Wiss. Arch. Landw. B.* **8**, 1, 1932.

51. STEUBER, M. and STOTZ, H. Ein Vergleich der aus der chemischen Analyse berechneten Stärkewert-Einheiten mit denen, die mit Hilfe des Tierversuches aus den gefundenen Verdauungskoeffizienten ermittelt wurden. *Wiss. Arch. Landw*, B. **5**, 188-200, 1931.

52. WOODMAN, H. E. and HANLEY, F. A study of the process of making stack silage. *J. Agric. Sci.* **16**, 24-50, 1926.

53. WOODMAN, H. E. The nutritive value of stack silage. Ryegrass and clover. *J. Agric. Sci.* **15**, 327-333, 1925.

54. ZAITSCHEK, A. Zur Bestimmung des Futterwertes von Wiesenheu. *Forts. Landw.* **5**, 721-23, 1930.